TM-868
1900.000

Fermilab

USER'S MANUAL FOR

MICROPROCESSOR - BASED SWIC SCANNER

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April 2, 1979

CONTENTS

I. Installing the Scanner

In order to function, the mircoprocessor-based SWIC scanner must be hooked to its SWIC and to its power supply. These connections are on the back of the scanner.

In addition, the scanner needs at least three other boxes:

1. a source of timing signals, usually a CAMAC Ø92 or Ø91 module,
2. a CAMAC Ø36 data transfer module, for transmitting commands to the scanner and receiving data from it,
3. a TV monitor or video modulator to provide the output display.

See System Diagram, Appendix 4

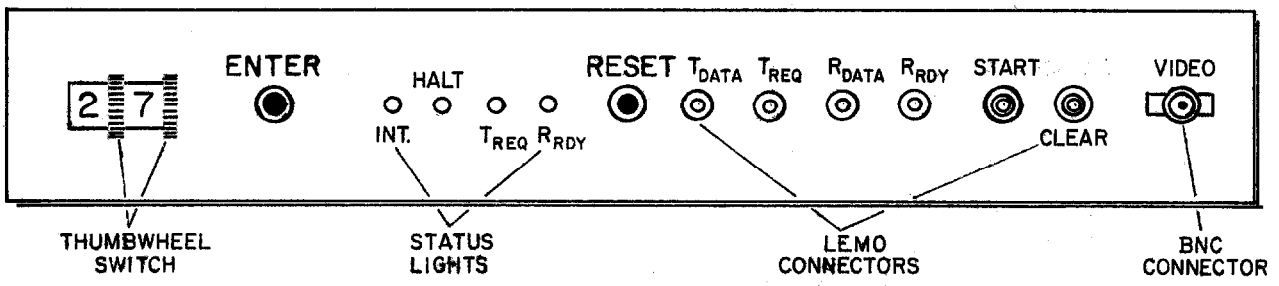
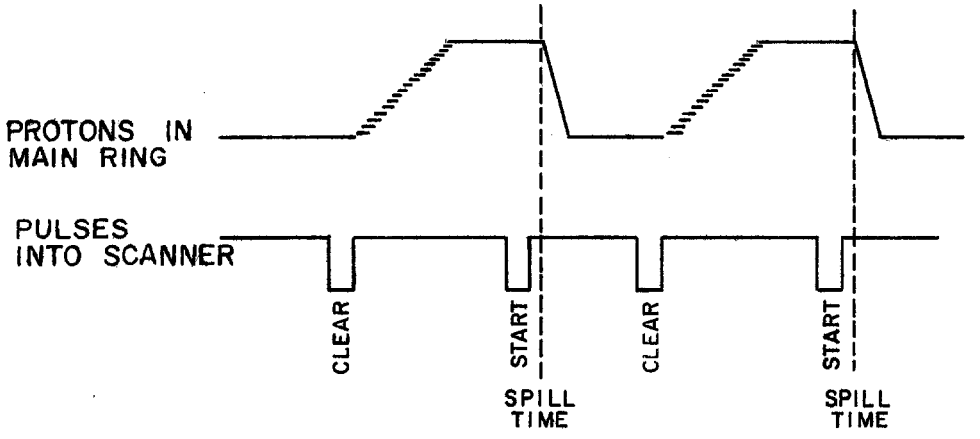


DIAGRAM OF SCANNER FRONT PANEL

A. Timing

Two kinds of timing pulses control the actions of the scanner. The "clear" pulse ends the previous data-taking period, regardless of the values of other parameters. It initializes the feature which subtracts background noise from the data. It also enables the scanner to accept a "start" pulse. Typically the "clear" pulse comes shortly before the "start" pulse, in order to provide the greatest possible active time before the next "clear" pulse.

The "start" pulse tells the scanner to begin taking data, i.e., connecting each SWIC wire to a capacitor which accumulates the charge on the wire. Usually the "start" pulse should come at, or just before, the beginning of a spill.



TYPICAL TIMING SCHEME

Both signals are introduced through LEMO connectors on the front of the scanner. While it is possible to use one timing module for each signal, it's simpler to obtain both from a single module. Connect the "start" cable to the T_{out} line on the Ø92 module. This is the signal whose arrival can be varied by programming the module remotely through the CAMAC system.

Connect the "clear" cable to the T_{ref} output of the Ø92. This pulse is constrained to arrive at one of the standard clock times of the accelerator cycle - T1, T2, etc. However, the user can choose which of these he wishes to employ.

T1 is usually a good choice, because there is no beam present at T1. It comes well after the previous spill, but still leaves a few seconds before the upcoming one. Lastly, since the time of a spill is usually quoted as a number of seconds following T1, it is easy to calculate timing information.

To set up the scanner timing, first phone the Main Control Room and find out when your spill comes in the accelerator cycle. Calculate the time at which you wish to begin taking data. Then sit down at your console and set your Ø92 module to this time.

For example, suppose the name of your module is TIMING, and you wish to send the "start" pulse 3.9 seconds after T1. Type:

S TIMING T 3.9, T1 ↵

T1 becomes the reference pulse, T_{ref}, and your "clear" pulse will be sent at T1. The "start" pulse will come 3.9 seconds later.

Be sure that your timing module is receiving a "clock in" signal from a predet or another timing module.

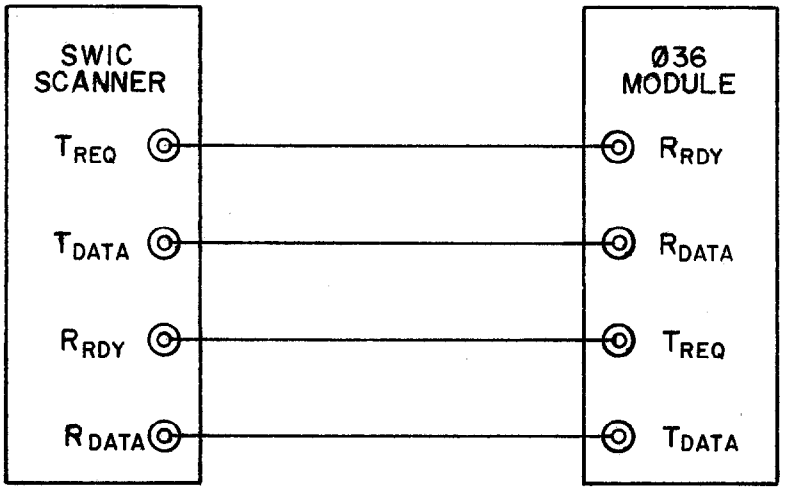
To use more than one "start" signal, see STORE MODE.

B. Data Transfer

The Ø36 data transfer module accepts commands from the CAMAC system and passes them along to the scanner. In some situations (see "Block Transfers in Store Mode") it may also accept beam profile data from the scanner.

Four cables are necessary between the Ø36 and the scanner: T_{data}, T_{req}, R_{data}, and R_{req}.

Because the scanner is receiving when the Ø36 is transmitting, and vice versa, these cables are hooked up in the following manner:



DATA TRANSFER CONNECTIONS

C. Video

The scanner produces a composite video signal as output. The BNC marked "video" should be connected to the video modulator for the desired channel or to a black-and-white TV monitor.

II. Issuing Commands to the Scanner

All communication with the scanner, through the Ø36 module connected to it*, is done in the TEST mode of the MAC. To enter data into the scanner, type

TEST ↵

The computer will respond with

LINK TEST!

Type CY, NZ, F9, x, F16, x ↵

where Y is the number of the crate, and Z the number of the slot, containing the Ø36 module. The signal "F9" causes the module's memories to clear. "X" is an order to execute the previous instruction, and must follow every instruction sent to the Ø36 module. "F16" means "Transmit the following instructions to the module."

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* The scanner can be programmed directly from its front panel. Set the two hex thumbwheel switches to the desired data byte, then press the "enter" button. For a reboot, it is necessary to press "enter" and "reset" simultaneously.

Now commands can be sent to the scanner. All commands are one byte (eight bits, or two hexadecimal digits) long. They must have either the form

DXMN,X

or the form

DXMNOP,X

where "DX" is a prefix meaning "Hexadecimal Data"; M, N, O, and P are hexadecimal numbers from Ø to F; and "X" is again the execute command.

In other words, commands can be transmitted one at a time or two at a time. Their numerical value is between ØØ and FF. They must always be preceded by DX and followed by a comma and X.

To get out of TEST mode, type Q).

WARNING: Do not issue illegal commands. For the unhappy results of such action, see the section "Illegal Commands".

A. Rebooting

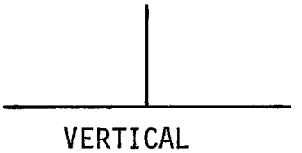
A "reboot" clears the scanner's memory of all data and resets the parameters to certain predetermined values. It also eliminates the characters in the NAME: portion of the display.

The reboot command is DXØ7,X.

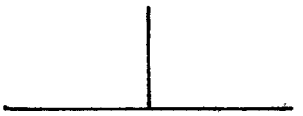
There are two ways to reboot the scanner from its front panel. Pressing both the "enter" and the "reset" buttons simultaneously executes a hardware reboot. A software reboot will occur when the thumbwheel switches are set to Ø7 and the "enter" button is pressed.

In either case, the display should go blank momentarily, then the following should appear:

NAME:
DISPLAY MODE
1 VGAIN 1
2 HGAIN 1
3 HOLD 1
4 CHARGE 1
5 POLARITY POS



VERTICAL



HORIZONTAL

SPACING MM

Parameter values other than these, or a change into Store Mode, must now be set by the user. Also the name of the SWIC must be entered in ASCII format.

(It is unwise to pair the reboot command Ø7 with any other byte, as in DXØ7AB,X. Stick to the single-byte format DXØ7 for this command.)

B. Illegal Commands

In general, the scanner is quite generous about ignoring illegal or unreasonable commands. However, occasionally such a command may cause the scanner's processor to freeze up, doing nothing and ignoring subsequent commands sent to it. To rescue it from this situation, a hardware self-rebooting feature has been provided.

If two "clear" pulses have entered the scanner, and the processor still ignores the outside world, then an automatic reboot takes place. This will free the scanner and return it to normal operation. Unfortunately, it also returns all parameters to their reboot values (see "Rebooting") and erases the scanner's name from its ACSII display.

The user who issues an illegal command will see nothing happen on the video display for a couple of cycles, then abruptly the display will blank and the post-reboot version will appear.

He must now re-enter his desired values of gain, polarity, etc., and the ASCII characters for the scanner's name.

C. Vertical Wire Gain

To set the gain of the display representing the SWIC's vertical wires, type in DX1N,X, where N is a hex integer from Ø to B (eleven). This gives a gain of 2^N.

At maximum gain, 2048, full scale indicates a charge collected on the wire of 128 picocoulombs.

Byte	Gain
DX1Ø	1
DX11	2
DX12	4
DX13	8
DX14	16
DX15	32
DX16	64
DX17	128
DX18	256
DX19	512
DX1A	1024
DX1B	2048

After a reboot (DXØ7), the vertical gain will be set to 1 automatically.

D. Horizontal Wire Gain

To set gain on the display representing the horizontal wires, type DX2N, where N is a hex integer from Ø to B (eleven). The gain will be set to 2^N.

Except for the first digit of the command byte (2 instead of 1), the horizontal gain behaves just like the vertical gain. After a reboot it will be set to 1.

E. Polarity

A given SWIC may operate with either positive or negative high voltage. Positive voltage applied to the wires collects the electrons which radiation knocks away from atoms of the counting gas. Negative voltage collects the positive ions thus formed.

The SWIC scanner is equipped to read SWICS of either polarity. To change the polarity, enter

DX5Y,X Y even - positive polarity
        Y odd - negative polarity

After a reboot the polarity will automatically be set to positive.

F. Charge Time

"Charge Time" is the length of time after the "start" pulse during which charge from the SWIC wires is allowed to collect on the scanner's capacitors. When charge time is over, the capacitor voltages are converted to counts and processed for display.

Charge time can be set from 1 millisecond up to 256/60, or about 4.27 seconds. To set charge time, type DX4N,X, where N is from this table:

N	Charge Time
0	1 msec
1	2 msec
2	4 msec
3	8 msec
4	1/60 sec (.016 sec)
5	2/60 (.033)
6	4/60 (.067)
7	8/60 (.133)
8	10/60 (.267)
9	32/60 (.533)
A	64/60 (1.07)
B	128/60 (2.13)
C	256/60 (4.27)

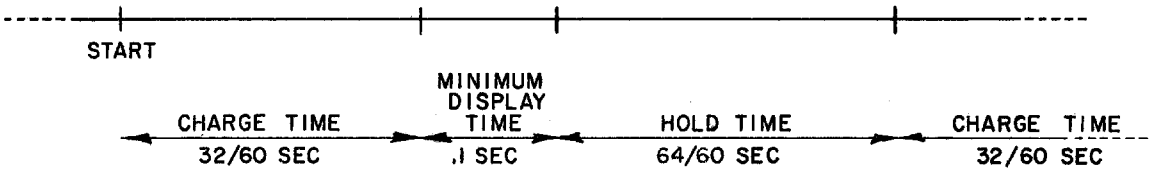
(Below 1/60 second, timing is taken from the crystal clock in the scanner. Above 1/60 second, timing comes from the 60 Hz AC line frequency. This helps to avoid 60 Hz interference, which can become nasty at high gains.)

G. Hold Time

(1) In Display Mode:

After the charge time is over, the scanner displays the data on the TV screen. This takes a minimum of 0.1 second. "Hold time" is the length of time after this minimum during which the display will remain on the screen. It can be set from 1 millisecond up to 256/60 seconds. To change hold time, type DX3N,X, where N is found from the table under "Charge Time" above.

For example, suppose the charge time is 32/60 second, and hold time is 64/60. After the "start" pulse is received, the scanner will "listen" to the SWIC wires for 32/60 second, counting the pulses on each wire. When the charge time is over, the display will be generated and will appear on the screen for .1 second, plus the 64/60 second hold time. Then the scanner will begin a new charge time. This cycle will repeat until a "clear" pulse is received.

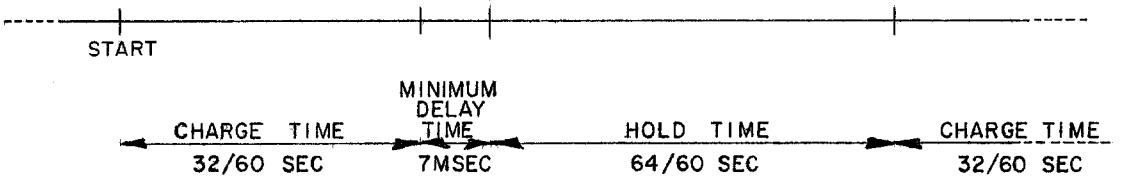


IN DISPLAY MODE

(2) In Store Mode, Internal:

Operation is similar to Display Mode except, since data are merely stored in memory and the display is not generated immediately, the delay between charge time and hold time is much shorter. Now there are only about 7 milliseconds of delay after charge time.

Hold time is still set by typing DX3N,X, where N is found from the table under "Charge Time".



(3) In Store Mode, External:

This mode is entered by selecting mode and typing DX3N,X, where N is D, E, or F. There is no hold time per se; instead the interval between charge times is determined by the arrival of succesive "start" pulses.

For more details see "Store Mode, External".

NOTE 1: If charge time is 1/60 second or greater, the scanner employs its 60 Hz line frequency clock. Then the hold time cannot be set to less than 1/60 second. Attempts to do so will default to 1/60.

NOTE 2: For complicated reasons, hold time must be regarded as only approximate, especially for settings less than 16/60 sec.

H. Mode Changes

The scanner can operate in Display Mode, in Store Mode, Internal or in Store Mode, External.

(1) Display Mode

In this mode the scanner "listens" or collects data from the SWIC for a specified length of time (the charge time), then displays the result for a while (hold time), then begins to "listen" again. These steps repeat until the scanner receives a "clear" pulse from its timing module. After receipt of another "start" pulse, the cycle begins again.

The Display Mode gives a real-time display in the sense that each scan or picture is displayed immediately after it is collected.

To put the scanner in Display Mode type DXØ5,X).

Display Mode also permits the scanner to accumulate counts over many scans and display their average. See "Accumulate".

(a) Accumulate

"Accumulate" is a function of the Display Mode only. For each wire it adds the total of counts acquired since the last "start" pulse and divides by sixteen. It can accept up to sixteen scans between "clear" pulses. The resulting display gives an average of the beam profile over all the scans.

Note that if the number of scans performed is less than sixteen, or if there is no beam for some of the scans, the profile will be much lower than that for a single scan. Thus it may be desirable to increase the gains while using the accumulate function.

To begin accumulating, type DXØ3,X. To end it, type DXØ4,X.

(2) Store Mode

In this mode, after a "start" pulse comes along, the scanner collects data for the duration of charge time, but instead of displaying the results, it stores them in its memory.

Store Mode can be operated with either of two variations. In Store Mode, Internal, charge time is followed by a set hold time, and then a new charge time, etc. In Store Mode, External, the scanner does nothing after charge time is over until it receives a second "start" pulse, which the user must supply.

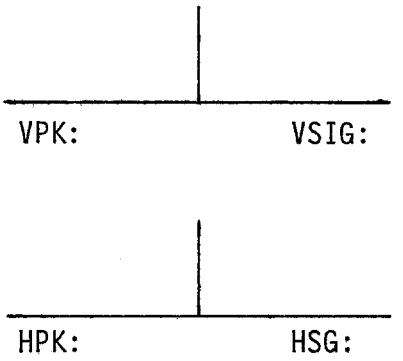
To enter either Store Mode type DXØ6,X. The following display will appear:

NAME:

Store Mode

1 VGAIN 1
2 HGAIN 1
3 HOLD 1
4 CHARGE 1
5 POLARITY POS
6 SCANS 1
7 ADD DISPLAY #
8 DEL DISPLAY #

123456789Ø (this row does not appear at first)



If gains, times, or polarity have been set to values other than the ones above, those values will remain upon transition to Store Mode. They are also unchanged through a transition from Store Mode to Display Mode.

After each scan, the scanner computes the best-fit Gaussian to the measured beam profile. The numbers HPK and VPK, under the graphs, give horizontal & vertical distance in millimeters from the center of this Gaussian to the center of the SWIC.

The numbers HSIG and VSIG give the sigma, or standard deviation, of the distribution in the horizontal & vertical directions. These values are a rough estimate of beam spot size.

The row of numbers at bottom left represents the scans chosen for display using the "add display" command. (The Ø stands for the

tenth scan.) The user types DX7N,X. If N is between 1 and A (ten), it appears on the screen in its proper position and the Nth scan will be displayed. If N is B (eleven) or greater, all ten scans will be displayed.

Of course, if any of the numbers thus selected is greater than the number specified with the "number of scans" command, DX6N,X, the scanner will simply ignore it.

When displays are generated, after all scans are completed, they are flashed on the screen one scan at a time. An asterisk will appear under the row of numbers to indicate which scan is currently displayed. So as the display flickers from scan to scan, the asterisk will march toward the right.

Store Mode, Internal is selected when the "Store Mode" command DXØ6,X is typed. Store Mode, External is selected with the additional command DX3D,X.

(3) Store Mode, Internal

Only a single "start" pulse is necessary. As in Display Mode, the scanner accumulates charge for the duration of charge time, then waits for a certain minimum time plus the length of hold time, then begins a new charge time. The cycle will repeat itself up to ten times, and the number of times can be set by the user with DX6N,X, the "number of scans" command.

The mimimum delay between charge time and hold time, as mentioned under "Hold Time", is much shorter than in Display Mode because the information is only read and stashed away in memory. There is no need to generate a video display immediately, so the delay is about seven milliseconds rather than one hundred.

Only after all the scans are finished are the displays generated. The user must select which of these he wants to view with the "add display" command, DX7N,X, where N is the number of the scan desired first, second, etc.

EXAMPLE:

Suppose a user sets up a charge time of 1/60 second, and a hold time of 4/60:

DX44,X, DX36,X↵

He enters Store Mode

DXØ6,X↵

and asks that five scans be performed after each "start" pulse.

DX65,X↵

For some reason, however, he is only interested in viewing the first, fourth, and fifth scans. So he adds these to his display:

DX71,X, DX74,X, DX75,X ↵

These numbers will appear in the last row on the left side of the display:

1 45

If he changes his mind and wants to eliminate the fourth scan, he can use the "delete display" command.

DX84,X ↵

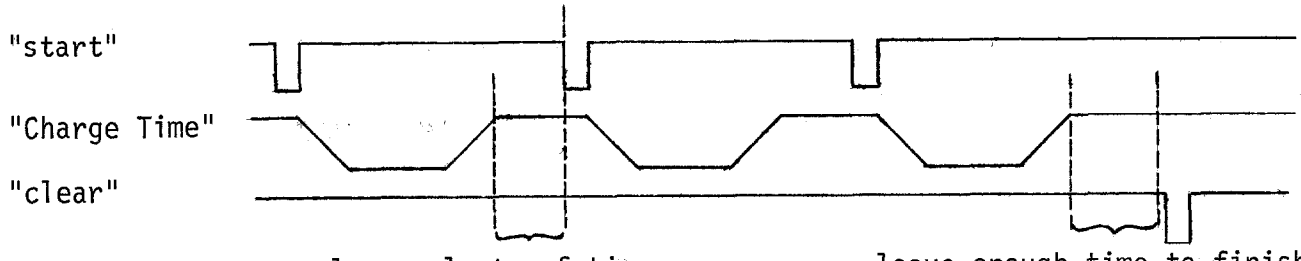
Then the numbers on the display will be

1 5

(4) Store Mode, External

The user must supply multiple "start" pulses in this mode if he wishes to perform more than one scan. It is useful for examining several features of the same accelerator cycle, such as multiple pings or slow and fast spills.

Since the "clear" pulse stops all data-taking, there must be enough time allowed for each "start" pulse and its associated charge time before a "clear". Also, charge times should be short enough so that they don't run into the next "start" pulse.



TIMING FOR STORE MODE, EXTERNAL

The "start" lines may be wired together using "T"-connectors from the outputs of Ø91 or Ø92 timing modules. Program the modules according to the above considerations.

Store Mode, External is entered by first entering Store Mode, Internal with DXØ6,X, then typing DX3D,X.

No displays will be generated until all scheduled "start" pulses have arrived and all scans are complete. So the scanner must be told how many pulses to expect, using the "number of scans" command, DX6N,X. If N is bigger than A (ten), the scanner assumes it's ten anyway.

As with Store Mode, Internal, not all scans need be displayed. The "add display" command, DX7N,X, and the "delete display" command, DX8N,X, select which scans will appear on the TV screen. If N is bigger than A (ten), it is interpreted to mean all scans. Again the asterisk below the row of numbers on the left will indicate the scan currently shown.

(5) Block Transfers in Store Mode

With the addition of certain equipment, the user may also employ block transfers to shuffle the stored SWIC data around the CAMAC system. He may want, for example, to give the beam profiles to an experimenter's computer to write onto tape. Such transfers are beyond the scope of this manual. If you need to know more about them, consult the Beam Systems Group responsible for your area. They may be contacted through the Crew Chief.

I. To Load ASCII Strings

Beside the word NAME: on the video display, there is provision to write two lines of ten characters each. In order to load characters into this space, you must first enter ASCII mode by sending DXØ1, which signals the device to interpret the following bytes as ASCII characters.

The text is entered as one or two bytes, preceded by DX and followed by a comma, X, and another comma. Once the carriage return is hit, the text on this line should appear immediately on the display. To space between characters, send the byte for a space, DX2Ø. To go to the second line, send the byte for carriage return, DXØD. For example, suppose the name of the scanner is FRED SMITH. Look up the ASCII for these letters in the table provided.

DXØ1,X ↵	(begin ASCII transmission)
DX4642,X, DX4544,X, DXØD,X ↵	(FRED carriage return)
DX534D,X, DX4953,X, DX48,X ↵	(SMITH)
DXØ2,X ↵	(End ASCII)

To exit the ASCII Mode, so that data bytes are interpreted in the normal manner, send DXØ2.

Should peculiar glitches appear in loading text, cope with them as best you can. If text appears in unwanted places, for instance, you may want to load spaces into those places:

DX2Ø2Ø,X, DX2Ø2Ø,X, ...

J. In Case of Trouble

If the scanner ignores your commands, or if the TV display is a meaningless hash, try rebooting it (type DXØ7,X) first.

If the scanner runs into trouble it may automatically reboot itself (see "Illegal Commands"). After such a hardware reboot, the parameters (gain, polarity, etc.) will revert to their reboot values, so you must re-enter the values and modes you desire.

Other items to check:

- correct timing signals - "start" and "clear" pulses
- correct crate and slot address for Ø36 and timing modules
- bad cables may lead to erratic data transfer.

* * *

I thank Jay Peterson and Carl Wegner of Beam Systems for extensive help in preparing this manual. My thanks also to Taka Kondo of the Neutrino Department for his support and valuable suggestions.

APPENDIX 1

Table of Scanner Commands

Each command is one byte, or two hexadecimal numbers, long. It has the form DXUL,X, where U is the upper number and L the lower number.

In general, U denotes the function which the command applies to, and L gives the particular value or action involved. For instance, in the command DX15,X the "1" indicates a gain change and the "5" means the gain will be set to 32, or in DXØ5,X, the "Ø" stands for a mode change while the "5" indicates Display Mode.

U-Values (Functions)

Ø Mode
1 Vertical Gain
2 Horizontal Gain
3 Hold Time
4 Charge Time
5 Polarity
6 Number of Scans
7 Add Display
8 Delete Display
D* transmit calculation results
E* transmit single-scan data
F* transmit block of scans

} Data Block Transfer

U = Ø Mode Change

DXØ1	Start ASCII
DXØ2	End ASCII
DXØ3	Start Accumulate
DXØ4	End Accumulate
DXØ5	Display Mode
DXØ6	Store Mode
DXØ7	Reboot

*Not within the scope of this manual

APPENDIX 1 (cont.)

U = 1 VERTICAL GAIN

DX1Ø	1
DX11	2
DX12	4
DX13	8
DX14	16
DX15	32
DX16	64
DX17	128
DX18	256
DX19	512
DX1A	1024
DX1B	2048

U = 2 HORIZONTAL GAIN

DX2Ø	1
DX21	2
DX22	4
DX23	8
DX24	16
DX25	32
DX26	64
DX27	128
DX28	256
DX29	512
DX2A	1024
DX2B	2048

U = 3 HOLD TIME

DX3Ø	1 msec
DX31	2 msec
DX32	4 msec
DX33	8 msec
DX34	1/60 sec (16.7 msec)
DX35	2/60 sec (33 msec)
DX36	4/60 sec (67 msec)
DX37	8/60 sec (133 msec)
DX38	16/60 sec (267 msec)
DX39	32/60 sec (533 msec)
DX3A	64/60 sec (1067 msec)
DX3B	128/60 sec (2133 msec)
DX3C	256/60 sec (4267 msec)
DX3D, DX3E, DX3F	Enter Store Mode, External

U = 4 CHARGE TIME

DX4Ø	1 msec
DX41	2 msec
DX42	4 msec
DX43	8 msec
DX44	1/60 sec (16.7 msec)
DX45	2/60 sec (33 msec)
DX46	4/60 sec (67 msec)
DX47	8/60 sec (133 msec)
DX48	16/60 sec (267 msec)
DX49	32/60 sec (533 msec)
DX4A	64/60 sec (1067 msec)
DX4B	128/60 sec (2133 msec)
DX4C	256/60 sec (4267 msec)

APPENDIX 1 (cont.)

U = 5 POLARITY

DX5N, N even - positive polarity (Ø to E)
DX5N, N odd - negative polarity (1 to F)

U = 6 NUMBER OF SCANS

DX6N, $1 \leq N \leq 9$ Perform N Scans
DX6N, $N \geq A$ Perform Ten Scans

U = 7 ADD DISPLAY

DX7N Display Scan Number N
$N \leq A$ (ten) - Display Individual Scan Number N
$N \geq$ - Display All Scans

U = 8 DELETE DISPLAY

DX8N Don't Display Scan Number N
$N \leq A$ - Delete Individual Scan #N From Display List
$N \geq B$ - Delete All Scans From List

APPENDIX 2

Hexadecimal Representation of ASCII Code

CHARACTER	HEX	CHARACTER	HEX	CHARACTER	HEX
A	DX41	Ø	DX3Ø	[	DX5D
B	DX42	1	DX31	.	DX2E
C	DX43	2	DX32	/	DX2F
D	DX44	3	DX33	Λ	DX5E
E	DX45	4	DX34	(dash) -	DX5F
F	DX46	5	DX35	@	DX4Ø
G	DX47	6	DX36	>	DX3E
H	DX48	7	DX37	?	DX3F
I	DX49	8	DX38	<	DX3C
J	DX4A	9	DX39	=	DX3D
K	DX4B	Space	DX2Ø	:	DX3A
L	DX4C	!	DX21	;	DX3B
M	DX4D	"	DX22	┴	DX82
N	DX4E	#	DX23	┘	DX83
O	DX4F	$	DX24	▒	DX1A
P	DX5Ø	%	DX25	Blanks Page	DX66
Q	DX51	&	DX26	Cursor →	DX67
R	DX52	'	DX27	Cursor ↓	DX68
S	DX53	(	DX28	Cursor ←	DX77
T	DX54	)	DX29	Cursor ↑	DX78
U	DX55	*	DX2A	No Cursor Advance	DX79
V	DX56	+	DX2B	Cursor Doesn't Move	DX75
W	DX57	,	DX2C		
X	DX58	(hyphen)-	DX2D	Doesn't Print Out	DX76
Y	DX59	]	DX5B	Carriage Return ↵	ØD
Z	DX5A	\	DX5C	Line Feed	ØA

APPENDIX 3

Sample Programming Conversation

(MAC computer responses are in lower case. The symbol ↵ stands for the carriage return key [CR].)

P ↵	Be certain you're out of page mode.
TEST ↵	Enter TEST mode.
link test!	Computer response - prompt character will be "?"
C2Ø, N8, F9, X, F16, X ↵	Address Crate 20, slot 8. Clear the registers of the module in this slot. Write the following into the module.
DXØ7,X ↵	Reboot the scanner.
DXØ1,X ↵	Enter ASCII mode to write the scanner's name
DX5357,X, DX4943,X, DXØD,X ↵ DX5343,S, DX414E,X, DX4E45,X ↵ DX52,X ↵	"SWIC ↵ " "Scanner"
DXØ2,X ↵	End ASCII mode.
DX15, X, DX24, X, DX51, X ↵	Set vertical gain to 32(15), set horizontal gain to 16(24), set polarity negative (51).
DX44, X ↵	Set charge time to 1/60 sec.
DX38,X ↵	Set hold time to 16/60 sec
DXØ6,X ↵	Put scanner in Store Mode, Internal
DX67,X ↵	Perform seven scans per accelerator cycle
DX71,X, DX72,X, DX76,X, DX77,X ↵	Display scans 1,2,6, and 7 each cycle
DX3D,X ↵	Put scanner in Store Mode, External
DX65,X ↵	Perform five scans per cycle. (Be sure timing hardware agrees with this!)
DX82,X, DX86,X, DX87,X ↵	Don't display scans 2,6, and 7
DX73,X, DX75,X ↵	Display scans 3 and 5 (Remember that scan 1 is also displayed.)
Q ↵	Exit TEST mode
console program!	Your console is now back to normal.